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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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OFFICE OF WATER

Dear Colleagues:

The U. S. Environmental Protection Agency is pleased to transmit a copy of the document entitled *Combined Sewer Overflows and the Multimetric Evaluation of Their Biological Effects: Case Studies in Ohio and New York*. This document reports on a project undertaken to measure the biological effects of combined sewer overflows (CSOs). CSOs are discharges to surface waters of mixtures of untreated domestic sewage, industrial and commercial wastewaters, and stormwater runoff. Concern has grown in recent years over the possible adverse ecological effects of CSOs. This concern was reflected in the 1994 CSO Control Policy, which identified the need for characterization of impacts on aquatic life and designated uses.

Aquatic biological communities are exposed to many environmental stressors, which may include point and nonpoint source pollution and habitat alteration or destruction. How the biological communities respond to and integrate these impacts are often difficult to interpret. However, biological assessment methods exist which are designed to evaluate and characterize biological integrity and to identify possible causes of the biological impacts. One of these is an EPA method known as rapid bioassessment protocols (RBPs). RBPs include standardized procedures to assess the biological status and habitat condition of streams, in comparison with minimally impacted streams of the same type. The biological assessment calculates multiple statistics (known as metrics) measuring different attributes of the aquatic community, such as species diversity, food chain relationships, and pollution sensitivity. The metrics are combined into one score of the overall biological status of the community. Interpretation of individual metrics may provide clues to causes of any impairment. Habitat assessments are conducted to determine if habitat degradation is a cause of biological impairment, alone or in combination with water quality problems. It consists of standardized methods to evaluate stream and riparian features important to healthy aquatic communities.

These case studies were carried out in Ohio and New York, both of which have well-established biological monitoring and assessment programs and which use methods similar in approach to RBPs. The availability of historic data allowed comparison of results between studies. The report also explores whether different levels of effort within the RBP framework affected the results. The purpose of this was to determine if using smaller sample sizes or a lower level of detail in organism identification would be sufficient for some purposes such as screening studies and establishing priorities. A final objective was to address possible applications of the RBP methodology in other aspects of watershed protection.

This document should not be construed as Agency guidance or policy, or as a requirement to use the RBP methodology. Rather, the intention of this document is to provide information on potential applications of RBPs and biological assessments. The document is aimed at state and local biologists and managers looking for potential tools to assess the biological effects of CSOs. It can be a tool to help prioritize limited resources where the CSO impacts are the greatest and where controls would do the most good.

Applications of RBPs are not limited to CSOs, however. Biological assessments have useful applications in various watershed protection approaches such as the TMDL process, 305(b) reporting, stormwater monitoring, and development of biological criteria. Bioassessments are useful screen tools for identifying and prioritization impaired waters. They may be able to provide an indication of causal relationships for different types of impairment such as habitat degradation, toxic loading, and organic enrichment. Finally, they may be useful in assessing how effective pollution control measures are in protecting aquatic life and biological integrity.

Requests for additional copies should be sent to U.S. Environmental Protection Agency, National Center for Environmental Publication and Information, 11029 Kenwood Road, Building 5, Cincinnati, Ohio 45242 (513-489-8190), or by email (Waterpubs@epamail.epa.gov.). Please refer to the EPA document number (EPA 823-R-96-002). For more information call Marjorie Coombs at 202-260-9821 (or via the Internet: coombs.marjorie@epamail.epa.gov).

We appreciate your interest in biological assessment and watershed management.

Sincerely,

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United States
Environmental Protection
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Washington, DC 20460

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EPA

Combined Sewer Overflows and the Multimetric Evaluation of Their Biological Effects: Case Studies in Ohio and New York

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Executive Summary

Combined sewer overflows (CSOs) are direct discharges into wetlands, lakes, coastal waters, streams, and rivers of untreated domestic, commercial, and industrial waste and wastewaters, and urban storm water runoff. They have recently received increased national attention because they are recognized as a primary contributor to water quality degradation in some urban areas, as identified by the President's Clean Water Initiative.

CSOs may have deleterious effects both on the designated recreational uses because of the pathogens found in raw sewage, and on the designated aquatic life uses because of adverse impacts on the biological community. These case studies were initiated to examine the effects of CSOs on the biological integrity of some example streams, using an established EPA protocol for biological assessment.

These projects focused upon several objectives:

1. Evaluation of the effectiveness of rapid bioassessment protocols (RBPs) for detecting biological responses to combined sewer overflows;

2. Comparison with historical assessments performed by the Ohio Environmental Protection Agency and the New York Department of Environmental Conservation;

3. Comparison of results from different levels of assessment rigor, in particular, of taxonomic identification level and subsample size; and

4. Evaluation of the potential application of bioassessment methods to the Total Maximum Daily Load (TMDL) process and other watershed protection approaches.

These case studies are intended for use by state bioassessment personnel, CSO management and control staff, and regional watershed protection coordinators. However, this document should not be construed as Agency guidance or policy, or as a requirement to use the RBP methodology in any given situation.

RBPs were applied at a total of 23 sampling stations in 10 streams and rivers in Ohio and New York. In Ohio, a subsample (300 organisms) was taken from each of 11 benthic macroinvertebrate samples; in New York, two subsamples (100 organisms and 200 organisms) were taken from each of 12 samples.

RBPs include a procedure to assess habitat quality, which was employed at each location. The procedure evaluates stream and riparian habitat features important to healthy aquatic communities such as channel width, depth, and sinuosity; instream cover (variety of substrate sizes, woody debris); riparian vegetation and canopy cover; and bank stability. Habitat assessments are conducted in order to determine if habitat degradation is a limiting factor for aquatic communities in the absence of, or in addition to, water quality problems.

RBPs also include an assessment of biological condition, which is based on an aggregation of several metrics calculated from the sampling results. These metrics are attributes of the community of aquatic organisms being sampled and are used to characterize the status of a stream. When compared with reference values, the aggregated metrics are an indicator of ecological condition. The metrics used in these studies include: taxa richness; Hilsenhoff Biotic Index (HBI); ratio of scrapers to filterer collectors; ratio of Ephemeroptera, Plecoptera, and Trichoptera (EPT) to Chironomidae; percent contribution of dominant taxon; EPT index; percent shredders; ratio of Hydropsychidae to total Trichoptera; Pinkham-Pearson Community Similarity Index; Quantitative Similarity Index (QSI)-Taxa; Dominants-In-Common (DIC)-5; and QSI-Functional Feeding Group (FFG).

RBPs were found to be useful in determining biological impairment due to CSOs and additional urban effects. Adverse biological responses to CSOs were identified at all stations downstream from CSO input. Responses included increased abundance of Chironomidae, increased abundance of filterer collectors, decreases in taxa richness, and an increase in HBI values. All of these biological responses indicate a shift from a well balanced community structure to one of increased tolerance of pollution. The responses are characteristic of nutrient and/or toxic loading.

Study areas in Ohio were selected based on the availability of data from previous biological assessments conducted by the Ohio Environmental Protection Agency (Ohio EPA) on rivers and streams impacted by CSOs. The three areas selected were the Scioto River at Columbus, the Sandusky River at Bucyrus, and the Little Cuyahoga River at Akron.

The Scioto River is a major tributary of the southern Ohio River and has a long history of degradation from a variety of sources including upstream water withdrawals, channel modifications, urban runoff, and input of organic matter, nutrients and toxics from CSOs. Historical monitoring by the Ohio EPA has generally resulted in biological assessment ratings as "poor" or "fair" in the Scioto near Columbus; assessment results from this study are consistent with the historical data. Habitat conditions at each station were judged to be similar so that any biological differences between stations should be due to water quality effects. The two stations within the zone of CSO influence were found to exhibit "moderate" and "slight" impairment relative to the regional reference station. Examination of the individual metrics indicate that the impairment may be due to organic enrichment and an increase in suspended organic particulates. The upstream reference station was found to have slight impairment relative to the regional reference. Review of individual metrics for the upstream station indicate that impairment was likely due to development, road runoff, and other human perturbations occurring upstream and adjacent to this station.

The Sandusky River is a major tributary to Lake Erie which runs through predominantly agricultural land in north central Ohio. Historical biological assessments of the Sandusky River at Bucyrus revealed significant impacts to the fish and macroinvertebrate communities from CSOs and the Bucyrus wastewater treatment plant (WWTP). In 1990, upgrades to the WWTP were made and corresponding improvements were reported in the biological condition. However, further historical assessments as well as current assessments indicate that slight impairment of the macroinvertebrate community remains downstream of CSO inputs. Impairment appears to be due to a combination of habitat degradation and water quality impacts associated with CSOs.

The Little Cuyahoga River flows through Akron in northeastern Ohio. The study area begins downstream of the Mogadore Reservoir. Historical assessments conducted by Ohio EPA indicate "fair" and "poor" biotic conditions due to a combination of urban runoff and organic enrichment problems from lake and wetland drainage. Current biological assessments indicate that the Little Cuyahoga has moderate biological impairment at the farthest downstream station; the upstream station was also assessed as having biological degradation. Habitat conditions were somewhat degraded at all stations along the Little Cuyahoga but were comparable at all three sites. Biological impairments at the downstream stations can thus be attributed to water quality. There was a distinct depression in overall biological condition at farthest downstream station, including decreased abundance and low diversity. This may possibly indicate the presence of toxicants contributed by CSO and/or industrial inputs. The middle station was originally expected to have been impacted by CSOs; however, the study results indicate improved conditions over the historical assessments. Further investigations revealed that the CSO outfalls upstream of the middle station had been recently eliminated. The biotic improvement over time shown at this station reflected their removal.

Three streams were also selected for the New York case study, Canastota Creek, Harbor Brook, and Onondaga Creek. These streams were selected by New York Department of Environmental Conservation for their known CSO-inputs and relevant historical assessment information.

Historical assessments of Canastota Creek indicate inputs of toxics as well as organic enrichment. Recent assessments (1990) indicate moderate impacts to the macroinvertebrate community in Canastota Creek. The current study found that the upstream station and the first CSO station were slightly to moderately impaired, likely due in part to organic enrichment occurring upstream of any CSO impacts. The downstream station was moderately impaired. Although the biological assessment score of the middle station was similar to that of the upstream station, examination of individual metrics found that the middle and downstream stations had a higher proportion of individual organisms considered to be pollution-tolerant, which is probably a response to CSO influence.

Habitat assessments on Harbor Brook indicated moderate impacts and severe impacts at the upstream and middle stations, respectively, as demonstrated by poor species richness and the high abundance of tolerant taxa. The results of the current study are consistent with these historical findings. Habitat conditions at the middle and downstream stations were very poor and the station farthest downstream on Harbor Brook was unable to be sampled due to severe habitat alterations (channelization), deep slow moving water, and a very soft bottom. The screening level assessment conducted at this site indicated severe biological impairment. Both the middle and downstream stations contained taxa considered to be tolerant to pollution and habitat degradation.

Historical assessments on Onondaga Creek correspond well to assessments conducted at the downstream station of the current study; both assessments indicated moderate to moderately-severe impairment. The upstream and middle stations on Onondaga Creek were found to be moderately impaired likely due to organic enrichment and habitat degradation.

The effectiveness of RBPs for detecting biological responses to CSOs was demonstrated through these case studies. Although "cause-and-effect" relationships are complicated by other problems associated with urbanization, such as habitat degradation and potential industrial discharges, reasonable support for attributing biological impairment to CSO effects was possible. Impairment due to CSO outfalls was noted in biological data in the historical assessments conducted by Ohio EPA and NYDEC, as well as in the current studies for all of the streams assessed. The upstream stations in the Scioto River, the Little Cuyahoga River, Canastota Creek, and Harbor Brook were all located in urbanized areas, yet the biological communities were of a high enough quality in comparison with the downstream stations to indicate that CSO outfalls had adverse effects on the macroinvertebrate communities.

Comparisons between the current studies and historical biological assessment results proved to be valuable; consistent comparisons were made with most historical assessments. In one instance where there were differences between historical and current results, i.e., the Little Cuyahoga River, the improvement in the biological assessment appears to be the result of removal of the CSO outfalls in that section of the river. Different sampling gears were used between the current and historical studies, therefore, only overall assessment results could be compared. Evaluation of how individual metrics or actual quantitative data differed among asessments was not possible.

Comparisons of individual metric values between different taxonomic levels showed some variability; however, total bioassessment scores (comparative ranking of sites) showed no difference. The appropriate level of taxonomic identification for a study is based on the study objectives; for other than screening-level assessments, the lowest possible level of identification is suggested. Several metrics use functional feeding group and tolerance value designations for their calculation (scraper-filterer collector ratio, percent shredders, QSI-FFG, and HBI). These are based on the knowledge of the ecology of macroinvertebrates at the species level. Therefore the uncertainty associated with the assignment of functional feeding group and tolerance value is greater the less detailed the identification is (e.g., genus, family, or order as opposed to species).

Subsample size had little effect on the rank order of total bioassessment scores. Metrics based on some form of taxa richness were variable with different subsample sizes, as expected, due to the increased probability of rare taxa being included in the larger subsample. However, as long as the test site and reference sites are treated in the same manner (i.e., same subsample size and taxonomic level), the biological assessment will be valid. Subsamples of 100 organisms are recommended in New York when using multimetric assessment approaches.

Biological assessments have useful applications in various watershed protection approaches such as the TMDL process, 305(b) reporting, stormwater monitoring, and development of biological criteria. Bioassessments are useful screening tools for identifying and prioritizing impaired waters. They may be able to provide an indication of causal relationships for different types of impairment such as habitat degradation, toxic loading and organic enrichment. Finally, they are useful in assessing how effective pollution control measures are in protecting aquatic life and biological integrity.

A limitation of this study is that, in nearly all cases, the farthest upstream stations showed some kind of impairment. Using impaired upstream stations as the control will often cause the downstream "affected" stations to appear better than they actually are. For increased accuracy, it is recommended that bioassessments use reference conditions composed of multiple reference sites, as opposed to single upstream reference sites.

Abstract

Combined sewer overflows (CSOs) are uncontrolled discharges, during wet and dry weather, of mixtures of untreated domestic sewage, industrial and commercial wastewaters, and stormwater runoff. There has been increasing interest in the effects of these discharges on the water quality and ecological integrity of surface waters receiving them. This document presents a discussion of the components of pollution produced by CSOs, the use of USEPA's rapid bioassessment protocols (RBPs) for evaluating instream community level effects on the benthic macroinvertebrate assemblage, and the potential for using bioassessment results in the total maximum daily load (TMDL) process, 305(b) reporting, biological criteria, and other watershed management efforts.

Application of the RBPs is presented in two case studies, in Ohio and New York, where assessments were completed and the results compared with historical assessments by the Ohio Environmental Protection Agency (Ohio EPA) and the New York Department of Environmental Conservation (NYDEC). Overall, the current assessments in Ohio are relatively consistent to Ohio EPA's assessments in 1986, 1988 and 1991; some assessment results varied slightly between the 1991 and 1992 surveys. The current assessments in New York are comparable to previous studies conducted by NYDEC in 1989 and 1990.

Also presented is an evaluation of the effects of the level of taxonomic identification and subsampling level on RBP results. When we compared two versions of the RBP methodology which employ different levelsof identification (family vs. genus or species), seven individual metrics showed variability with the changing taxonomic level while the total bioassessment scores were not affected. Results using family level identifications may be less sensitive than genus/species level for those metrics that depend on tolerance values and functional feeding group designation. Although the total bioassessment scores were not affected, the variability of the individual metrics, and lower taxonomic resolution, can lead to difficulties in interpreting the findings of the total bioassessment scores when family level identification is used. Comparisons between two different subsample sizes (100 and 300 organisms) also showed no differences in the total bioassessment scores; only two metrics (taxa richness and EPT index) performed differently between the subsampling efforts.

The results presented indicate that bioassessments, in general, and RBPs, specifically, are found to be effective in detecting the biological effects of CSOs.